PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-145516

(43)Date of publication of application : 28.05.1999

(51)Int.Cl. H01L 33/00
H01L 21/20

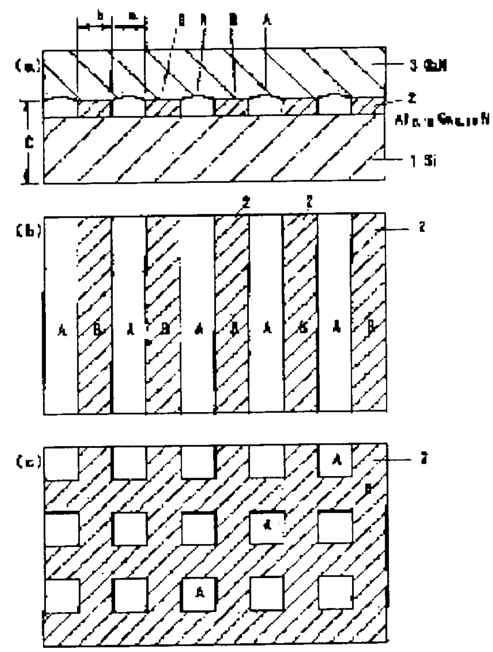
(21)Application number : 09-322132

(22)Date of filing : 07.11.1997

(71)Applicant : TOYODA GOSEI CO LTD

(72)Inventor : KOIDE NORIKATSU

(54) MANUFACTURE OF GALLIUM NITRIDE COMPOUND SEMICONDUCTOR



(57)Abstract:

PROBLEM TO BE SOLVED: To improve elemental characteristics, while carrying out the manufacture which has good efficiency by forming a gallium nitride semiconductor layer having no cracks or dislocations.

SOLUTION: An Al0.15Ga0.85N layer 2 is formed onto a silicon substrate 1 in a stripe shape or a lattice shape. A GaN layer 3 is grown in the exposed regions A of the substrate 1 and the upper regions B of the layer 2. GaN is grown three-dimensionally on the Al0.15Ga0.85N of the layer 2 epitaxially (not only in the vertical direction but also in the lateral direction) at this time. Accordingly, since GaN is grown in the epitaxial manner in the lateral direction as well, the gallium nitride compound semiconductor, in which the dislocations are reduced greatly, can be obtained in the lateral growth regions as the exposed regions A of the substrate 1.

LEGAL STATUS

[Date of request for examination] 17.09.1999

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than

the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3036495
[Date of registration]	25.02.2000
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the gallium-nitride system compound semiconductor and its manufacture technique of general formula Alx Gay In1-x-y N (0<=x<=1, 0<=y<=1, 0 <=x+y <=1). It is related with the technique which used longitudinal direction epitaxial growth (ELO) on the substrate especially.
[0002]
[Description of the Prior Art] Since an emission spectrum is ultraviolet, it is a transited [directly] type semiconductor over a red large area, and a gallium-nitride system compound semiconductor is light emitting diode (Light Emitting Diode). It is applied to light emitting devices, such as a laser diode (LD). In this gallium-nitride system compound semiconductor, it usually forms on sapphire.
[0003]
[Problem(s) to be Solved by the Invention] However, with the above-mentioned conventional technique, when a gallium-nitride system compound semiconductor is formed on silicon on sapphire, according to the coefficient-of-thermal-expansion difference of sapphire and a gallium-nitride system compound semiconductor, a crack and camber occur in a semiconductor layer, the trusion occurs by the mistake foot, and, for this reason, there is a problem that an element property is not good.
[0004] Therefore, it is forming the gallium-nitride system semiconductor layer without a crack and the trusion in view of the above-mentioned technical probrem, and the purpose of this invention is realizing the efficient manufacture technique while it raises an element property.
[0005]
[Means for Solving the Problem and its Function and Effect] In order to solve the above-mentioned technical probrem, a means according to claim 1 Grow up the 1st gallium-nitride system compound semiconductor on a substrate, and after that, the 1st gallium-nitride system compound semiconductor so that the outcrops of a substrate may be scattered Although it etches into island status, such as the shape of punctiform, the shape of a stripe, and a grid, and it grows up after that considering the 1st gallium-nitride system compound semiconductor of the island status as a nucleus The 2nd gallium-nitride system compound semiconductor which does not grow epitaxially considering the outcrop of a substrate as a nucleus is grown up, and the exposed-surface top of a substrate is the manufacture technique of the gallium-nitride system compound semiconductor characterized by forming by longitudinal direction growth.
[0006] In addition, longitudinal direction here means the orientation of a field of a substrate. Thereby, the 2nd gallium-nitride system compound semiconductor does not grow up to be the outcrop of a substrate, but on the 1st gallium-nitride system compound semiconductor, grows also in-like 3-dimensional ** and the orientation of a field, and grows uniformly by above [of a substrate]. Consequently, the trusion based on the misfit between a substrate and a gallium-nitride system compound semiconductor grows up to be lengthwise, and

does not grow up to be longitudinal direction. Therefore, the lengthwise penetration trusion of the 2nd gallium-nitride system compound semiconductor on the outcrop of a substrate is lost, and, only in the fraction on the 1st gallium-nitride system compound semiconductor, the lengthwise penetration trusion remains. Consequently, the surface density of the lengthwise penetration trusion of the 2nd gallium-nitride system compound semiconductor decreases extremely. Therefore, the crystallinity of the 2nd gallium-nitride system compound semiconductor improves. Moreover, since the outcrop of a substrate and the 2nd gallium-nitride system compound semiconductor on it are not joined chemically, while the camber of the 2nd gallium-nitride system compound semiconductor is prevented, it is suppressed that stress asymmetry goes into the semiconductor.

[0007] Invention of a claim 2 is having made the substrate into sapphire, silicon, or the silicon carbide, and can raise the crystallinity of the 2nd gallium-nitride system compound semiconductor obtained on the substrate of ******.

[0008] It is characterized by invention of a claim 3 making the gallium-nitride system compound semiconductor and the 2nd gallium-nitride system compound semiconductor which contain aluminum for the 1st gallium-nitride system compound semiconductor formed in silicon and the island status in a substrate the gallium-nitride system compound semiconductor which does not contain aluminum. Although the gallium-nitride system compound semiconductor containing aluminum grows epitaxially on silicon, the gallium-nitride system compound semiconductor which does not contain aluminum does not grow epitaxially on silicon. Therefore, although the 1st gallium-nitride system compound semiconductor of the island status is formed on a silicon substrate and it grows epitaxially on the 1st gallium-nitride system compound semiconductor after that, the 2nd gallium-nitride system compound semiconductor not growing epitaxially can be formed in the outcrop of a silicon substrate. Thereby, the 1st gallium-nitride system compound semiconductor is used as a nucleus, the 2nd gallium-nitride system compound semiconductor will grow epitaxially in longitudinal direction, and the outcrop top of a silicon substrate can obtain a crystalline high gallium-nitride system compound semiconductor.

[0009]

[Embodiments of the Invention] Hereafter, this invention is explained based on a concrete example.
(The 1st example) View 1 is the ** type view having shown the cross-section configuration of the gallium-nitride system compound semiconductor concerning the 1st example of this invention. On the silicon substrate 1, aluminum0.15Ga0.85N layer (1st gallium-nitride system compound semiconductor) 2 of thickness about 1000 ** are formed the shape (drawing 1 (b)) of a stripe, and in the shape of a grid (drawing 1 (c)). Moreover, in exposed-region A except the layer 2 on a silicon substrate 1, and top field B of a layer 2, it is GaN of about 10 micrometers of thicknesss. The layer (2nd gallium-nitride system compound semiconductor) 3 is formed.

[0010] Next, this GaN The manufacture technique of a system compound semiconductor is explained. This semiconductor was manufactured by the sputtering method and the organic-metal vapor growth (it abbreviates to "MOVPE" below). MOVPE The used gas is ammonia (NH3), carrier gas (H2, N2), trimethylgallium (Ga3 (CH3)) (it is described as "TMG" below), and a trimethylaluminum (aluminum3 (CH3)) (it is described as "TMA" below).

[0011] first, it washed using the fluoric acid system solution (HF:H2O=1:1) (111) a field and a field (100) -- or (110) The susceptor laid in the reaction chamber of MOVPE equipment is equipped with the n-silicon substrate 1 which made the field the principal plane. Next, the substrate 1 was baked at the temperature of 1150 degrees C, passing H2 to a reaction chamber for about 10 minutes by part for rate-of-flow 2 liter/by the ordinary pressure.

[0012] The temperature of a substrate 1 is held at 1150 degrees C. N2 or H2 A part for then, 10liter/, NH3 A part for 10liter/, and TMG A part for 1.0 x10 -four mols/, A trimethylaluminum (aluminum3 (CH3)) (it is described as "TMA" below) A part for 1.0 x10 -five mols/, It is 0.86 ppm by H2 gas. The diluted silane is

supplied by part for 20x10 -eight mols/, and it is aluminum0.15Ga0.85N of thickness about 1000** and 1.0x1018/cm3 of Si concentration. The layer 2 was formed.

[0013] Next, on this layer 2, uniformly, SiO two-layer was formed by sputtering at thickness about 2000 **, the resist was applied, and it etched SiO two-layer into the predetermined configuration by the photolithography. Next, dry etching of aluminum0.15Ga0.85N layer 2 was carried out, having used the SiO two-layer of this predetermined configuration as the mask. Thus, width-of-face b of up field B of a layer 2 formed the shape (drawing 1 (c)) of the shape (drawing 1 (b)) of a stripe, and a grid whose spacing a of about 5 micrometers and exposed-region A of a substrate 1 is about 5 micrometers.

[0014] Next, MOVPE Temperature of a substrate 1 is made into 1100 degrees C by the method, and they are a part for 20liter/, and NH3 about N2 or H2. A part for 10liter/, and TMG It is 0.86 ppm by 1.0 x10 -four mol a part for /and H2 gas. The diluted silane is supplied by part for 20x10 -eight mols/, and it is GaN of about 10 micrometers of thicknesss. The layer 3 was grown epitaxially. At this time, it is GaN. aluminum0.15Ga0.85N On a layer 2, it is these aluminum0.15Ga0.85N. It considers as a nucleus and grows epitaxially. However, on exposed-region A of a silicon substrate 1, it is GaN. It does not grow epitaxially. And at exposed-region A of a silicon substrate 1, it is aluminum0.15Ga0.85N. GaN which grew on the layer 2 It considers as a nucleus and is GaN. It grows epitaxially along with the longitudinal direction of a field, i.e., the orientation of a silicon substrate 1. This GaN A layer 3 is aluminum0.15Ga0.85N. The trusion arises only in up field B of a layer 2 lengthwise, and in exposed-region A of a silicon substrate 1, since it is lateral epitaxial growth, the trusion is not produced. It is aluminum0.15Ga0.85N about the area of exposed-region A of a silicon substrate 1. By enlarging compared with the area of up field B of a layer 2, it crosses to a large area, and is GaN with good crystallinity. A layer 3 can be formed. Moreover, a silicon substrate 1 and GaN on it Since it has not joined together chemically, it is GaN. The camber of a layer 3 and stress asymmetry can be decreased very greatly.

[0015] In addition, it is good GaN, if it is needed for lateral growth for a long time when width-of-face a of exposed-region A exceeds 10 micrometers and width-of-face a of exposed-region A of a silicon substrate 1 is set to less than 1 micrometer, although width-of-face a of exposed-region A of the silicon substrate 1 formed the shape of a stripe and in the shape of a grid was set to about 5 micrometers in the above-mentioned example. Since membranous formation becomes difficult, the domain of 1-10 micrometers is desirably good. Moreover, aluminum0.15Ga0.85N Although width-of-face b of up field B of a layer 2 was set to 5 micrometers aluminum0.15Ga0.85N If width-of-face b of up field B of a layer 2 exceeds 10 micrometers, the probability of trusion occurrence will increase, if width-of-face b of up field B is set to less than 1 micrometer, nucleation for lateral growth will not be made by being good, therefore epitaxial growth of crystalline good longitudinal direction becomes difficult. Therefore, the domain of 1-10 micrometers is desirably good. Moreover, aluminum0.15Ga0.85N of width-of-face a of exposed-region A of the crystalline viewpoint of a layer 3 to the silicon substrate 1 As for the rates a/b over width-of-face b of up field B of a layer 2, 1-10 are desirable.

[0016] In addition, in the above-mentioned example, although the silicon substrate was used, other conductive substrates, silicon on sapphire, a silicon carbide, etc. can be used. When a conductive substrate is used, an electrode can be formed in the best layer of the element layer formed on the rear face of a substrate, and the substrate, a current can be passed at right angles to a substrate side, and the current supply luminous efficacy in light emitting diode, laser, etc. improves. At this example, it is aluminum0.15Ga0.85N about composition of a layer 2. Although carried out, the gallium-nitride system compound semiconductor of general formula Alx Gay In1-x-y N (0<=x<=1, 0<=y<=1, 0 <=x+y <=1) of an arbitrary composition ratio can be used. In order to make it grow epitaxially on a silicon substrate 1, it is Alx Ga1-x N (0 < x<=1) (AlN is included). It is desirable. Moreover, the gallium-nitride system compound semiconductor of general formula Alx Gay In1-x-y N (0<=x<=1, 0<=y<=1, 0 <=x+y <=1) of an arbitrary composition ratio can be used for a layer 3, and although it may be a different composition ratio even if it is the same composition ratio as a layer 2, it needs

to make it the composition ratio which does not grow epitaxially to a substrate. Moreover, in this example, although the thickness of a layer 2 was made into about 1000**, if a layer 2 is thick, its crack will increase, and if thin, a layer 3 will not grow, using a layer 2 as a nucleus. Therefore, the thickness of a layer 2 has desirable 500 ** - 2000**.

[0017] (The 2nd example) At the 1st above-mentioned example, it is aluminum0.15Ga0.85N as 1st gallium-nitride system compound semiconductor. Only one layer of layers 2 is formed. At this example, it is aluminum0.15Ga0.85N as 1st gallium-nitride system compound semiconductor. A layer 21 and GaN on it It is characterized by forming by two-layer [of a layer 22].

[0018] Drawing 2 is a ** type view having shown the cross-section configuration of the gallium-nitride system compound semiconductor concerning the 2nd example of this invention. On a silicon substrate 1, aluminum0.15Ga0.85N layer 21 of thickness about 1000 ** is formed, and it is GaN of thickness about 1000 ** on this layer 21. The layer 22 is formed. The 1st gallium-nitride system compound semiconductor consists of a layer 21 and a layer 22. 22 layers of these layers 21 and layers are formed the shape of a stripe, and in the shape of a grid as well as the 1st example. On the layer 22 and exposed-region A of a silicon substrate 1, the GaN layer 3 of about 10 micrometers of thicknesss is formed.

[0019] In the 1st example, after the gallium-nitride system compound semiconductor of this 2nd example forms a layer 21 and the layer 22 uniformly on a silicon substrate 1, it uses the SiO two-layer of a predetermined pattern as a mask, and as shown in the drawing 1 (b) or (c), it makes a layer 21 and the layer 22 the shape of the shape of a stripe, and a grid by dry etching. Subsequent GaN Formation of a layer 3 is the same as that of the 1st example.

[0020] GaN of about 10 micrometers of thicknesss The growth process of a layer 3 is as follows. GaN GaN GaN of up field B of a layer 22 It considers as a nucleus and grows up perpendicularly in a field. And GaN which grew on exposed-region B of a layer 22 in exposed-region A of a silicon substrate 1 It considers as a nucleus and GaN grows epitaxially in longitudinal direction. Thus, at this example, it is GaN. GaN Since it considers as a nucleus and it grows epitaxially also to lengthwise also at longitudinal direction, it is GaN with still high crystallinity from the 1st example. It is obtained.

[0021] In addition, it sets to this example and is GaN about a layer 22 and the layer 3. Although carried out, it is good also considering a layer 22 and the layer 3 as a gallium-nitride system compound semiconductor of general formula Alx Gay In1-x-y N (0<=x<=1, 0<=y<=1, 0 <=x+y <=1) of the same composition ratio. However, let a layer 2 be the composition ratio which does not grow epitaxially to a substrate. When silicon is used for a substrate, it is good to use the gallium-nitride system compound semiconductor in which aluminum is not contained. Of course, you may change the composition ratio of 6 of a layer 22 and the layer 2, and the 2nd layer 3.

[0022] It is GaN of the non-trusion by removing partial C to the layer 2 or the layer 22 from the silicon substrate 1 or the silicon substrate 1 by polishing or etching in all the above-mentioned examples. A substrate can be obtained. It sets in all the above-mentioned examples, and is GaN to a layer 3. Although used, it is InGaN of an arbitrary composition ratio. You may use. Moreover, you may form the semiconductor layer of other materials on a layer 3. The element with the good property of light emitting diode, laser, etc. can be obtained by growing up a gallium-nitride system compound semiconductor further especially. Moreover, it sets in all the above-mentioned examples, and is AlGaN of an arbitrary composition ratio between a substrate 1, the layer 2, or the layer 22. Buffer layer You may prepare the buffer layer of AlGaInN. This buffer layer carries out the crystal structure of the amorphous grade in which the shape of amorphous [which is formed at low temperature rather than the single crystal growth temperature of a layer 2 and the layer 22] or the microcrystal was intermingled.

[0023] The light emitting diode and laser with quantum structures, such as SQW or MQW, can be formed as an element layer. It sets in all the above-mentioned examples, and is MOVPE. Although the method was performed in the ordinary-pressure ambient atmosphere, you may perform it under reduced pressure growth.

Moreover, you may carry out in the combination of an ordinary pressure and reduced pressure. GaN obtained by this invention A system compound semiconductor can be used also for a photo detector and an electronic device while it can be used for the light emitting device of Light Emitting Diode or LD.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] Grow up the 1st gallium-nitride system compound semiconductor on a substrate, and after that, the 1st gallium-nitride system compound semiconductor so that the outcrops of the aforementioned substrate may be scattered Although it etches into island status, such as the shape of punctiform, the shape of a stripe, and a grid, and it grows up after that considering the gallium-nitride system compound semiconductor of the above 1st of the aforementioned island status as a nucleus It is the manufacture technique of the gallium-nitride system compound semiconductor which the 2nd gallium-nitride system compound semiconductor which does not grow epitaxially considering the outcrop of the aforementioned substrate as a nucleus is grown up, and is characterized by forming the exposed-surface top of the aforementioned substrate by longitudinal direction growth.
[Claim 2] The aforementioned substrate is the manufacture technique of sapphire, silicon, or the gallium-nitride system compound semiconductor according to claim 1 characterized by being a silicon carbide.
[Claim 3] It is the manufacture technique of the gallium-nitride system compound semiconductor according to claim 1 characterized by ** and the gallium-nitride system compound semiconductor of the above 2nd being gallium-nitride system compound semiconductors which do not contain aluminum in the gallium-nitride system compound semiconductor in which the gallium-nitride system compound semiconductor of the above 1st which the aforementioned substrate is silicon and is formed in the aforementioned island status contains aluminum.

[Translation done.]